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HIGH YIELDS FROM 100-YEAR-OLD PONDEROSA PINE

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ABSTRACT

A 100-year-old stand of ponderosa pine on a good site responded in diameter growth to a thinning from above that removed 20 percent of the volume or 16 percent of the basal area. Impressive periodic annual volume increments were produced in both thinned and unthinned stands during the 30 years of observation. Total net yield of thinned and unthinned stands at 126 years was 62,500 board feet (International 1/8-inch) per acre. Mortality, caused by mountain pine beetle in small merchantable trees, suggests that similar stands should be thinned lightly and frequently from below.

Keywords: Ponderosa pine, *Pinus ponderosa*, yield (forest), growth response, thinnings (stand volume).

Ponderosa pine (*Pinus ponderosa*) growth east of the Cascades is regarded by most laymen and some foresters as slow. This is due largely to observations of vast areas of old mature timber growing at minimal rates. This note reports some impressive growth in a 100-year-old stand on a good site where tree numbers had been reduced to low-density levels by repeated ground fires and a thinning from above. Such information hints at production possibilities under management and gives us insight as to when and how to manage these highly productive stands. In addition we also have an opportunity to compare actual stand growth with Meyer's normal yield tables, Technical Bulletin 630.[1] For direct comparison with Meyer, we have used International 1/8-inch board-foot rule and total cubic feet.

THE TIMBER STAND

The stand (fig. 1) is located on the Lookout Mountain Unit of the Pringle Falls Experimental Forest 35 miles southwest of Bend in central Oregon. Study plots are on an east slope at an elevation of about 4,600 feet. The *Pinus ponderosa/Ceanothus velutinus* plant community[2] (in an *Abies concolor/Ceanothus velutinus* climax association) covers extensive areas on the mountainside. In the study area, snowbrush ceanothus (*Ceanothus velutinus*) predominates with an occasional golden chinkapin (*Castanopsis chrysophylla*). Western prince's pine (*Chimaphila umbellata*) is abundant.

Soil consists of a Mount Mazama pumice mantle 3 to 4 feet deep underlain by a sandy loam Paleosol developed in older volcanic ash. Average annual precipitation is estimated between 25 and 35 inches.

Seedlings became established following a hot fire about 1840. Repeated ground fires thereafter and intermittent beetle activity reduced density to around 280 trees per acre when the study was established. At this time trees averaged a little over 12 inches in diameter and 80 feet tall. About half the trees were from 9 to 15 inches in diameter at breast height, 30 percent were less than 9 inches, and 20 percent were 15 to 25 inches.

The plots to be thinned contained about 6,500 cubic feet and 37,000 board feet (International 1/8-inch, 6.6-inch and larger d.b.h. to a 6-inch top d.i.b.)

1/ Walter H. Meyer. Yield of even-aged stands of ponderosa pine. U.S. Department of Agriculture Technical Bulletin 630 (revised), 59 p., illus. 1961.

2/ Jerry F. Franklin and C. T. Dyrness. Natural vegetation of Oregon and Washington. USDA Forest Service Technical Report PNW-8, p. 176-177. Pacific Northwest Forest and Range Experiment Station, Portland, Oreg., 1973.

Figure 1.--The timber on Lookout Mountain adjacent to the study area. Stand is about 100 years old.

(table 1). The plots left unthinned contained slightly more volume. Basal area and cubic volume on the thinned and unthinned plots were about 6 percent above Meyer's normal before thinning.

Although no crown measurements were made, several observers thought that tree crowns were short and narrow relative to tree height.

The stand consists almost entirely of ponderosa pine, with an occasional lodgepole pine. Some loss from suppression and beetle attack is evident, although the stand is free of serious diseases.

THE STUDY

In 1938 a 40-acre portion of the 94-year-old stand was thinned from above. Just before thinning, all trees were measured and a stand table constructed. Some heights were measured and volume estimates made to aid in applying thinning treatment. However, trees left after thinning were not tagged until 1940. Thus, the 30-year period of detailed growth observation did not start until two growing seasons after thinning.

Cutting in the thinned area removed an average of 23 trees per acre or 20 percent of an original volume of 6,500 cubic feet per acre, leaving 5,200 cubic feet (table 1). About 9,300 board feet were removed from an original volume of 37,000 board feet. Dominants and codominants removed in this thinning averaged about 17.0 inches in diameter. There was notable variation between plots, although plots were reasonably uniform within

Table 1.--*Stand characteristics before and after thinning and amount removed in thinning*

[Per acre. Derived from stand tally information made at time of cutting]

Plot number	Number of trees			Basal area			Average diameter[1]			Cubic volume[2]			International volume[3]		
	Before	Removed	After	Before	Removed	After	Before	Removed[4]	After	Before	Removed	After	Before	Removed	After
				----*Square feet*----			--------*Inches*--------			------*Cubic feet*------			--------*Board feet*--------		
Thinned:															
2	266	18	248	212	31	181	12.1	17.7	11.6	6,111	1,002	5,109	33,187	6,674	26,513
3	184	32	152	214	57	157	14.6	18.1	13.7	6,824	2,051	4,733	44,317	16,142	28,175
4	370	12	358	226	18	208	10.6	16.6	10.3	6,008	568	5,440	29,770	3,831	25,939
5	258	22	236	223	36	187	12.6	17.2	12.1	6,665	1,210	5,455	40,270	9,650	30,620
6	276	30	246	228	41	187	12.3	15.8	11.8	6,864	1,508	5,356	38,506	9,970	28,536
Average	271	23	248	219	35	184	12.2	16.8	11.6	6,494	1,268	5,219	37,210	9,253	27,957
Unthinned:															
7	390	--	--	275	--	--	11.4	--	--	7,993	--	--	42,913	--	--
8	184	--	--	186	--	--	13.6	--	--	5,694	--	--	35,119	--	--
Average	287	--	--	230	--	--	12.5	--	--	6,844	--	--	39,016	--	--

1/ Quadratic mean.

2/ Total volume of entire stem inside bark, trees 2.6-inch d.b.h. and larger.

3/ International 1/8-inch rule (to convert to 1/4-inch, multiply by 0.90476); trees 6.6-inch d.b.h. and larger to a 6-inch top d.i.b.

4/ Removed tree measurements as of 1938 when thinning was made.

themselves. Although early records did not indicate any intent to sample extremes in stand density, this may have been the intent.

Seven permanent plots were established (table 2), five in the thinned and two in an unthinned portion. Three of the thinned plots were 0.5 acre and the rest 1 acre. At the beginning of the detailed growth study in 1940, diameters of all trees were measured at breast height to the nearest 0.1 inch. Heights of about 45 trees per plot representing the complete range of diameters were measured with an abney. Plot volumes were calculated using equations of the form $\log_e$ volume = a + b $\log_e$ diameter fitted to the sample tree values of diameter and corresponding volumes as estimated by table 32 (total cubic) and table 33 (International 1/8-inch rule) in Technical Bulletin 630.

Estimates of 1938 volumes of cut trees were calculated from a stand table made at the time of cutting. The volume equation developed for each plot during the first period was used to estimate 1938 volumes. No attempt was made to measure growth from 1938 to 1940, because measurements in 1938 were not made with the same precision as those in 1940. Volume estimates differ slightly from those published in 1947[3/] because of the method of volume computation.

At the time of thinning, stump ring counts of 121 dominant and codominant trees indicated the stand to be an average of 94 years old. Apparently variation in age from tree to tree was small. This age was further substantiated in 1973 from recently logged trees adjacent to study plots. Except for one tree which exhibited a core of six closely spaced rings in the center, there was little evidence of severe competition for space in early years.

3/ Edwin L. Mowat. High yields from young-growth ponderosa pine. USDA Forest Service Pacific Northwest Forest and Range Experiment Station Research Note 37, 3 p. Portland, Oreg., 1947.

Table 2.--*Stand characteristics 2 years after thinning and three periodic intervals thereafter*

[Per acre]

Plot number	Age	Site index[1]	Number of trees	D.b.h. average[2]	Height average[3]	Basal area	Cubic volume[4]	International volume[5]
	Years			*Inches*	*--Feet--*	*Square feet*	*Cubic feet*	*Board feet*
Thinned:	96		248	11.6	79	181	5,303	28,083
2	107	86	225	12.8	84	202	6,302	36,554
	117		212	13.7	89	218	7,291	44,406
	126		197	14.6	94	228	8,084	51,335
	96		152	13.7	84	156	4,925	29,755
3	107	91	136	15.2	92	171	5,884	38,097
	117		126	16.3	99	183	6,759	45,222
	126		122	17.1	104	194	7,572	51,721
	96		358	10.4	70	209	5,681	27,871
4	107	79	284	12.0	79	223	6,820	38,162
	117		262	13.0	86	241	8,006	47,781
	126		236	14.1	92	255	8,930	56,157
	96		236	12.1	80	188	5,657	32,346
5	107	88	208	13.4	87	203	6,648	41,445
	117		186	14.5	92	214	7,434	49,119
	126		168	15.5	97	220	8,044	54,854
	96		246	11.8	76	186	5,539	29,970
6	107	88	205	13.3	84	197	6,384	37,999
	117		178	14.6	90	208	7,227	45,359
	126		165	15.6	96	220	8,125	52,823
Average	96		248	11.9	78	184	5,421	29,605
	107	86	212	13.3	85	199	6,408	38,451
	117		193	14.4	91	213	7,343	46,377
	126		178	15.4	96	224	8,151	53,378
Unthinned:	96		390	11.4	76	275	8,233	44,913
7	107	88	308	12.9	84	281	9,261	55,493
	117		262	14.1	92	286	10,178	64,438
	126		204	15.3	99	261	9,811	64,567
	96		184	13.6	84	186	5,948	37,149
8	107	94	164	15.1	95	204	7,295	48,236
	117		137	16.6	103	206	7,944	54,225
	126		129	17.5	108	215	8,708	60,472
Average	96		287	12.5	80	231	7,090	41,031
	107	91	236	14.0	89	242	8,278	51,864
	117		199	15.4	97	246	9,061	59,332
	126		166	16.4	104	238	9,260	62,520

1/ Technical Bulletin 630.

2/ Quadratic mean.

3/ Average height corresponding to quadratic mean diameter.

4/ Cubic volume of trees 2.6-inch d.b.h. and larger.

5/ International 1/8-inch scale; trees 6.6-inch d.b.h. and larger to a 6-inch top d.i.b.

RESULTS

DIAMETER GROWTH

Even though these trees were approaching 100 years, they did respond to thinning. Average annual diameter increment per surviving tree was as follows:

Period	Thinned	Unthinned	Difference
	--------------	Inches	--------------
1940-51	0.0734	0.0610	0.0124
1951-61	.0622	.0545	.0077
1961-70	.0580	.0510	.0070

Response to release was greatest during the first growth period. Diameter increment averaged about 17 percent better on the thinned plots the first period and only 12 percent the last two periods. Many small trees had no measurable increment from one period to another. Some large trees, with full crowns and ample growing space, grew 2.5 inches per decade. On the other hand, not all large trees grew fast. Each plot contained a few 15- to 20-inch trees that did not add any detectable increment from one period to the next. A typical average range of increments with tree diameter is shown by the linear regressions in figure 2 (r^2 values ranged from 51 to 59 percent). No direct relationship between diameter growth and the amount of release a given tree received could be established during the first growth period.[4/]

MORTALITY

Almost all mortality could be attributed to mountain pine beetle (*Dendroctonus ponderosae*). In the last period, volume of mortality increased to about 77 percent more in the unthinned plots than in the thinned (table 3). Evidently unthinned density increased to a point ideal for beetle development. Mortality was consistently lower in the thinned than the unthinned plot throughout the 30-year period of growth observation.

Mortality often occurred in dense tree groups. Usually, suppressed or intermediate trees from 4 to 10 inches in diameter were the most susceptible. Occasionally trees over 20 inches would succumb to attack of the insect. This occurred in one of the unthinned plots during the last period

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[4/] Unpublished progress report on file at the Pacific Northwest Forest and Range Experiment Station, Silviculture Laboratory, Bend, Oreg.

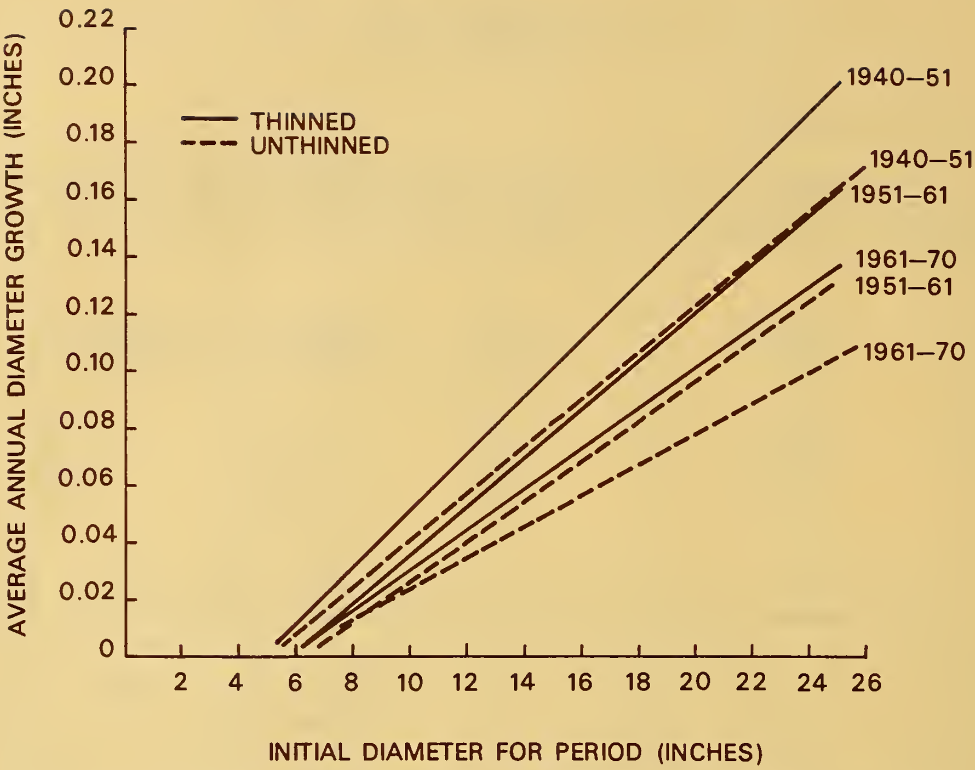

Figure 2.--Average annual diameter increment of trees of given diameter in thinned and unthinned plots.

Table 3.--*Periodic annual net and gross increments and mortality during the 30 years of growth observation*

[Per acre]

Treatment	Growth period	Periodic annual net volume increment		Periodic annual mortality		Periodic annual gross volume increment	
		Board feet	*Cubic feet*	*Board feet*	*Cubic feet*	*Board feet*	*Cubic feet*
Thinned	1940-51	804	90	62	22	866	112
	1951-61	793	94	57	16	850	110
	1961-70	778	90	76	19	854	109
Unthinned	1940-51	985	108	102	30	1,087	138
	1951-61	747	78	220	44	967	122
	1961-70	354	22	489	84	843	106

where there were 262 trees and basal area was over 280 square feet per acre. Of 58 trees that died in this plot during the last period, 60 percent had no measurable increment the previous period and 95 percent were growing at rates less than 0.8 inch per decade. Fifty-three percent of these trees were merchantable (10-inch or more diameter breast height) and could have been harvested.

VOLUME INCREMENT

Gross periodic annual volume increment averaged greater on the unthinned plots during the first and second periods (table 3 and figs. 3 and 4). During the last period, thinned and unthinned plots were about equal. Net increment, on the other hand, was higher on the unthinned plots only during the first period. Mortality increased during the second and third periods; on one unthinned plot, mortality was so high that no net yield resulted. Total net yield of the thinned (including volume removed in thinning) and unthinned plots at 126 years (1970) was about 62,500 board feet per acre.

On a tree-by-tree basis,large dominants are growing 10 to 18 board feet per year. And, in many instances about half the total board-foot volume produced was grown on only the 40 largest diameter trees per acre. This is contrasted to many small but merchantable trees growing less than a board foot a year. For example, plot 6 (table 2) had 36 trees in this category in the last period, 22 of which would be merchantable under present day standards in central Oregon. This suggests that a thinning from below, removing many small unproductive trees, may not reduce growth appreciably, yet it will permit utilization of mortality that is likely to occur within the

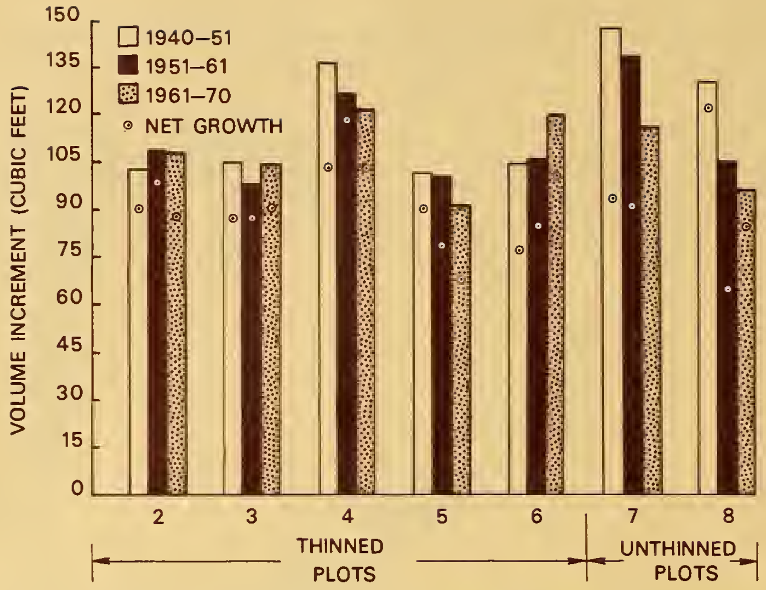

Figure 3.--Periodic annual net and gross cubic volume increment per acre.

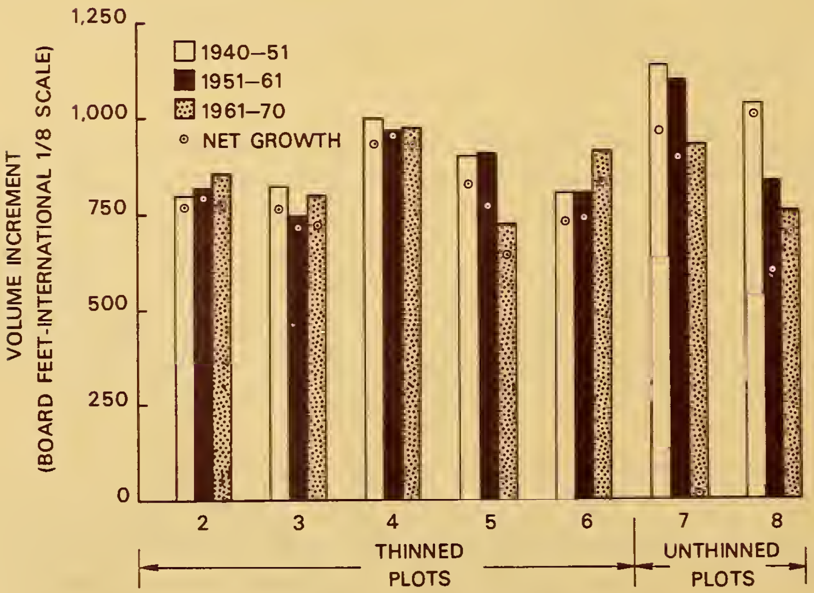

Figure 4.--Periodic annual net and gross board-foot volume increment per acre (International 1/8-inch rule).

decade. Also, the few large trees that are not adding any increment could be cut if detectable at the time of marking.

During the 30 years of observation, annual growth of the thinned plots averaged 857 board feet per acre gross and 791 net (table 3), increments that are far above normal stand values. An average increase in site index of 2.5 points took place during the 30 years of observation. This in itself would account for an annual increment of about 85 board feet per acre in the yield table but does not account for increment values far above normal in this study. In terms of cubic volume, net increment was over 250 percent of normal yield table growth in the thinned area (table 4), even though cubic stand volume was cut 12 percent below normal. One is tempted to suspect that the height growth characteristics of this stand may be quite different from those reflected in Technical Bulletin 630.

Table 4.--*Comparison of total cubic volume, basal area, and net cubic volume increment with Meyer's normal yield table (Technical Bulletin 630)*

Plot	Stand volume		Basal area		Periodic annual increment	
	1940	1970	1940	1970	1940-51	1961-70
	Percent of normal stand values					
Average, thinned	88	115	89	108	257	321
Average, unthinned	105	120	108	111	258	73

DISCUSSION AND CONCLUSIONS

Even though this stand may be rotation age, it is producing impressive amounts of wood annually that are far in excess of what might be anticipated from Meyer's yield table. Because of age and poor crown ratios, most trees in this stand do not have the capacity to respond dramatically to thinning. Even so, this unmanaged stand, thinned late in the rotation, responded to thinning. Evidently small increases on large tall trees resulted in substantial growth per acre.

Thirty-year growth in the thinned plots remained nearly constant, while that in the unthinned declined. Over the 30 years, thinned plots grew less gross cubic wood than unthinned. However, net increment of thinned plots averaged considerably higher than unthinned.

Although this stand is growing above normal, we probably should not conclude that all similar stands are going to perform as well as this one. For some reason the productivity potential for this area is high for the measured site index. The capacity of a site index class to have more than one productivity potential has been recognized for some time,[5] and this may be what has happened in this stand.

Although this stand was thinned from above, the pattern of mortality during the 30 years of observation would suggest that light thinnings from below with removal of an occasional poor tree from above would maintain the productive capacity of the stand and permit utilization of mortality that is likely to occur.

The public land manager with large acreages of low-producing, overmature, and diseased timber often faces a difficult decision. Should he concentrate all of his allowable cut in old-growth stands to convert them more quickly to fast-growing, young stands? Or should he do some commercial thinning in stands such as described in this note? Obviously the major portion of the cut should come from old-growth stands. However, if a minimum of effort can be expended in thinning these 100-year-old stands gently but frequently, it is possible to avoid wasting wood through mortality and thus increase the total amount available for cutting. Excessive cutting in these 100-year-old stands to forestall mortality would slow down old-growth conversion efforts and would ultimately result in an overall loss in productivity.

On the other hand, private landowners without a large reserve of old growth may wish to liquidate a large portion of the growing stock in a stand of this type.

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[5] E. Assmann. The principles of forest yield study. New York: Pergamon Press, 506 p., illus., 1970.

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